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Energy situation in Mozambique: A review

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ABSTRACT

The need to increase energy security and promote development, especially in rural areas has forced many developing countries in southern Africa, like Mozambique to take several actions toward development of several infrastructures and legislations for production and use of liquid biofuels. The main objective of this study is to present the energy situation in Mozambique and assess the potential for energy generation from widely available renewable sources including residues from agricultural crops and forest industry. The country is endowed with great potential for biofuels, solar, hydro and wind energy production. The energy production today is, however, far from fulfilling energy needs of the country, and the majority of people are still not benefiting from these resources. The potential of total residues from agricultural sector and forest industry is estimated to be around 128 PJ. This amount of energy covers almost half of the combined production of charcoal and firewood which amounted to approximately 298 PJ in 2006. However, such amount of energy resources is wasted and is not visible on national energy statistics.

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Contents

1. Introduction

The world's economy today is heavily dependent on fossil fuel, which will continue to be the dominant source of energy for the next two to three decades [1]. The challenge of energy security and sustainability, the environmental issues and oil price are the drives behind the search for alternative sources of energy.

The annual worldwide energy demand is over 400 EJ/year [2] and biomass represents approximately 10 [3] to 14% [4,5] of the

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world's energy consumption. The world has less than 4 billion hectares of forest covering 30% of earth's land area [6], of which about 95% are natural forests and only 5% are plantations [7]. The harvesting of wood fuels is simply the largest use of forests worldwide accounting for 61% of total removals, equivalent to 2443 million m^3 [8], which contributes with 25 and 83% of total energy consumed in developed and developing countries, respectively [9].

Deforestation, predominantly in Africa and South America, continues at a very high rate of about 13 million hectares per year worldwide [6,10]. Nevertheless, forest plantation and natural expansion has significantly reduced the net loss of forest area [4].

In developing countries like Mozambique, wood fuel is used inefficiently in its raw form, thus wasting much of the energy available and contributing to unhealthy environment. Every year, about 1.6 million people worldwide, of which 400,000 are from Sub-Saharan Africa, die prematurely, mainly women and children due to exposure to indoor air pollution from wood fuel combustion. It is expected to increase to almost 9.8 million deaths by 2030 [10]. In addition to that, precious time and efforts are spent on fuel collection instead of education or income generation [11].

Firewood is the predominant fuel used in the rural areas of developing countries, while charcoal is the preferred fuel in urban centres [12,10]. Africa consumes over 50% of the charcoal produced worldwide, the majority of which is consumed by households for cooking and heating and the rest by commerce and industry [13].

The need to increase energy security and promote development, especially in rural areas has forced many developing countries in southern Africa, especially Mozambique to take several actions toward development of infrastructure as well as legislation for production and use of liquid biofuels. However, many of such actions seem to be uncoordinated and many gaps and questions still need to be addressed.

The main objective of this study is to analyse the energy situation in Mozambique and assess the potential for energy production from the widely available renewable sources including residues from agricultural crops and forest industry.

2. Background

Mozambique is located on the east coast of Southern Africa on the Indian Ocean, between latitude 10°27′S and 26°52′S and longitudes of 30°12′W and 40°51′W. The country has a total area of 801,590 km^2, of which 2% is inland water [15,16]. The climate varies from tropical and subtropical, comprised by dry winter season from April to September and a rainy summer season from October to March [14–16]. The mean annual rain ranges from 800 to 1000 mm along the coast, 1200 mm in the central region and between 1000 and 2000 mm in the northern region [17].

About 78% of the territory is covered by trees or other woody vegetations. Productive forests incorporate vegetation types where trees and bushes occupy at least 20 million ha or 25% of the terrestrial surface of Mozambique [18]. The annual allowable cut is around 520,000–640,000 m^3/year. It is commonly known, however, that 50–70% of the total national production is illegally harvested [19]. The reported level of exploitation is at 175,283 m^3/year [20], which is well below the annual allowable cut even when the "unreported" volumes are included.

The wood exploitation, among 120 different species, is concentrated mainly on three of them; jambire (*Millettia stuhlmannii*), chanfuta (*Afzelia quanzensis*) and umbila (*Pterocarpus angolensis*), which represent 78% of total volume commercialised [20]. Apart from wood exploitation, charcoal production, shifting cultivation and uncontrolled forest fires are some of the main causes of forest degradation, being responsible for an annual loss of

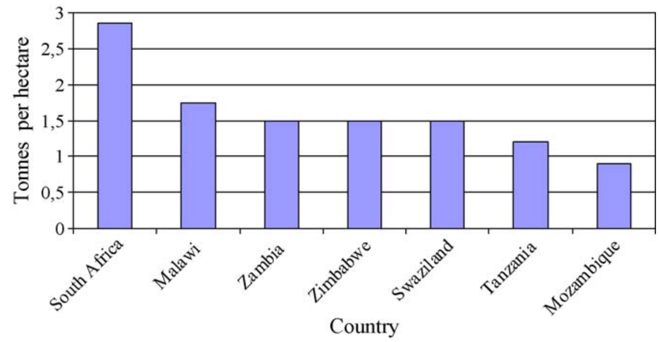


Fig. 1. Maize yield in SADC countries [17].

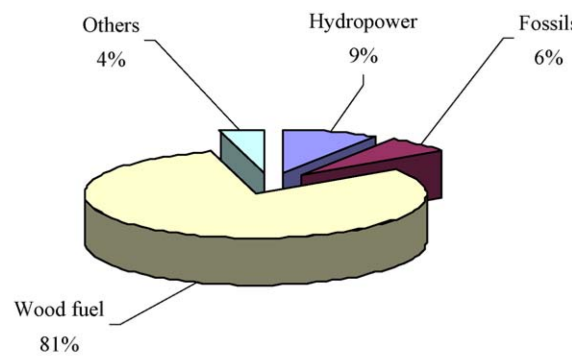


Fig. 2. Balance of energy consumed in Mozambique in 2006.Source: [44].

6–10 million ha. About 90% of the forest fires are due to human activity, mainly agriculture and hunting [21].

Mozambique is considered as one of the poorest countries in the world, with 54% of the population below the poverty line [15,16,22] despite achieving very high economic growth during the last years [14,23,24]. Total population is estimated at around 20.4 million with 63% living in rural areas [16].

Subsistence agriculture employs about 80% of the labour force [15,16,25], which accounts for about 21.1% of GDP [26]. In rural areas, agriculture is the main activity for 95% of the households [24,27]. Despite that, the average crop yield is still about half of the regional (Southern African Development Community – SADC) standard estimates [17] as illustrated in Fig. 1. The land and all natural resources belong to the state, which guarantees user rights to local communities, local and foreign investors.

The main sources of energy in the country are biomass, hydroelectric power (dams), solar power, liquid fossil fuels (gasoline and petroleum) and natural gas [28] (Fig. 2). To reduce the dependence on imported fuels, great attention has been given to liquid biofuels in recent years. Moreover, it is believed that biofuels can contribute to the development of rural areas through the utilization and marketing of locally available resources, provide job opportunities and help to alleviate poverty.

3. Fossil fuels

3.1. Oil products

Mozambique uses imported oil and oil products. The average oil import bill is about US$270 million, equivalent to 14.6% of total national imports. The annual domestic consumption of oil products is about 700,000 m^3 [29].

Considerable oil exploration possibilities exist in the provinces of Gaza, Inhambane, Sofala, Zambezia, Nampula, Cabo Delgado,

Table 1
Consumption calculated by sum of sales in internal market (tonnes). Figures within brackets shows the changes of consumer selling price during 2000–2006 (%) [29].

Product	2000	2001	2002	2003	2004	2005	2006
LPG[a]	7856	8056	8619	10,166	12,399	13,801	12,834
	(60.1)	(46.2)	(7.6)	(−2.5)	(−12.0)	(103.7)	(47.6)
Petrol	53,328	60,198	64,267	69,534	67,156	80,474	72,395
	(38.2)	(0.1)	(20.2)	(44.4)	(18.5)	(87.9)	(−1.2)
Jet A-1 Kerosene	42,496	37,998	38,684	38,175	39,786	43,781	53,799
	(96.0)	(−1.2)	(19.5)	(30.2)	(17.9)	(99.5)	(−10.3)
Diesel	281,182	264,762	307,460	326,696	323,457	327,782	317,615
	(103.9)	(5.5)	(22.5)	(31.0)	(8.4)	(68.5)	(−4.0)
Diesel oil	14,862	17,086	17,690	22,922	22,710	7823	1907
	(33.1)	(39.5)	(38.6)	(−2.9)	(1.8)	(60.9)	(79.7)
Kerosene for lighting	50,400	40,817	36,532	35,655	37,081	33,690	27,660
	(151.1)	(−1.0)	(21.0)	(28.1)	(13.2)	(57.9)	(13.9)
Total	450,123	428,917	473,253	503,148	502,590	507,350	486,211

[a] Liquefied petroleum gas.

and related offshore areas. The government opened a bidding round in July 2005 for the exploration of several offshore blocks in an area known geologically as the Rovuma Basin, named for the Rovuma River that forms Mozambique's northern boundary with Tanzania [30].

The stocking capacity is very limited, which makes the country very sensitive to variations in oil price (Table 1). To minimize the effect of such variations several projects are ongoing in Maputo, Beira and Nacala to increase the stock capacity to about 829,000 m^3. A 450-km pipeline for oil transportation will be built from Kendal, Witbank (RSA), crossing Nelspruit to Matola, Maputo (Mozambique), with a capacity to transport 5 million m^3/year [29].

In general, the consumption and the price of oil products increased between 2000 and 2006, except for the consumption of kerosene for lighting. The lower consumption can be related to increased access to electricity, as shown in Table 6. In 2000, the price of diesel showed its highest increase, while petrol reached a price increment peak by 2005.

3.2. Coal

Concerning coal resources, Mozambique has three relatively large known deposits at Moatize-Minjova, Senangoe and Mucanha-Vanduzi, all in the Province of Tete. Total coal reserves are estimated at about 2.4 billion tonnes [30].

The production of coal has been limited in recent years because of the damage to the Sena rail line during the civil war in the 1980s, which cut off the access of Moatize coal field to overseas markets [31]. Presently, the mine is being developed by Brazilian coal company *Companhia Vale do Rio Doce* (*CVRD*) to produce 14 million tonnes of coal per year. Much of this is intended for export and the remains will fuel a 2000 MW thermal power station at the mine site. The mines life has been calculated to about 35 years [30,32].

3.3. Natural gas

Presently three accumulations of gas have been discovered on-shore in Pande and Temane, province of Inhambane, Buzi Province of Sofala. Total gas reserves might be as high as 3.5 trillion cubic feet. The installed system in Pande has a capacity of 120 million GJ/year (3.1 billion m^3). Almost all production is now being exported to South Africa through a 865-km pipeline linking the locality of Temane, in Inhambane in Mozambique, and Sekonda, in the province of Gauteng in South Africa. Only 1.2% of the production is locally used, mainly by the industry (1.1%) and the rest is used for electricity generation [29].

The utilization of natural gas in the industrial production processes is limited only to 15 companies all in Maputo area. A pilot experiment in gas-powered private vehicles and public buses are underway, although some technical and costs to convert the ordinary vehicles (petrol and diesel) to gas users has been referred to as the main barriers to spread the experience all over the country.

Despite the increase of 62.8% in total gas consumption during 2000–2006, the commerce and service sector showed drastic reduction in their gas consumption (−68.3%) while gas consumed for electricity generation and by residential sector grow steadily during the same period (Table 2).

4. Renewables

4.1. Biomass energy demand and supply

Mozambique was identified as one of the promising regions for biomass production in tropical Africa and it has been estimated to have a capacity to produce up to 6.7 EJ/year (higher heating value) of biomass with moderate introduction of agricultural technology and meeting basic sustainability criteria such as protecting forests and fulfilling growing food demands [40].

4.1.1. Firewood and charcoal

Wood is the major household energy source in Mozambique. The production capacity of firewood and charcoal is estimated at 22 million tonnes/year. With the present energy demand of around 14.8 million tonnes/year, a positive balance of 7.2 million tonnes/year is evident [41]. However, average efficiency of fuelwood used in households is estimated to be ≤10%, which results in a relatively

Table 2
Natural gas consumption in Mozambique, GJ, 2000–2006 [29].

	2000	2001	2002	2003	2004	2005	2006
Electricity generation	31,373	43,741	92,323	100,175	108,449	101,163	109,289
Industry	0	0	0	0	0	719,025	1,180,890
Commerce and Services	619	1002	1221	1508	8601	7204	2720
Residential	260	529	858	1161	1755	2402	2518
Non-classified	6683	7013	7271	3117	0	0	0

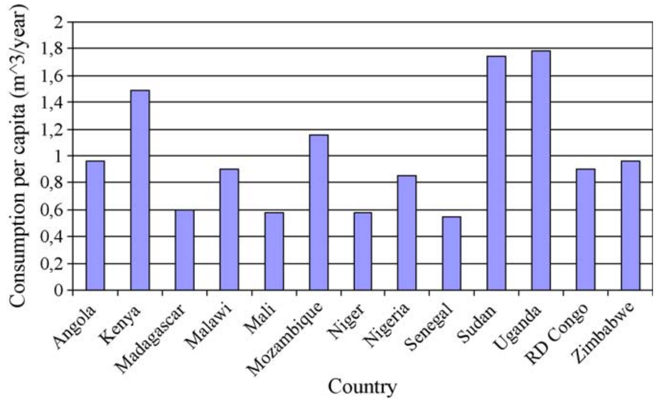


Fig. 3. Wood fuel consumption per capita of some African countries.Source: adapted from [13,41].

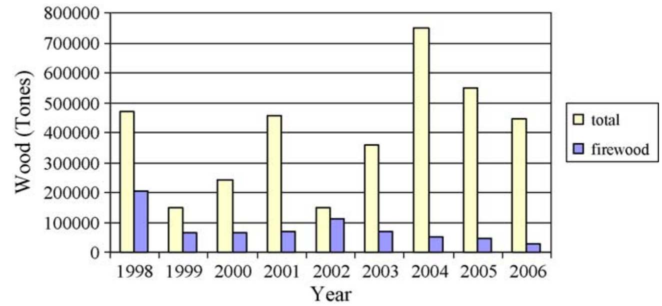


Fig. 4. Total wood fuel licensed and share of firewood in Mozambique.Source: adapted from [41].

high national average wood fuel consumption per capita in the country, as shown in Fig. 3.

Despite the reliance of 70% of people on firewood, its use has not been reported as cause of concern for forest, because only dead wood and woodcut for other purposes are collected [11,26,49]. The production of charcoal, on the other hand, has been referred to as one of the main causes of deforestation in Mozambique. An increased demand for charcoal in the urban centres of the country has resulted in localised deforestation in vulnerable areas, particularly surrounding the major cities [57]. The annual average per capita consumption of wood fuel in urban areas is estimated at 1.2 m^3 compared to 1.0 m^3 in rural areas [41].

In the late 1980s the natural vegetation within the radius of 50–60 km around Maputo had been practically removed. In 1993 the forest was located within a radius of 60–100 km and further increase by 1999 to 150–200 km. Presently, Maputo is receiving charcoal and firewood from Inhambane and Sofala, 600-km away [42]. Consequently, the price of charcoal and firewood in Maputo is the highest in the country. This can be seen not only as an indicator of the deforestation on areas surrounding Maputo, but also as an incentive for those living in the productions areas of charcoal and firewood to increase their production and consequently lead to further deforestation.

The natural forest is the main source of biomass for energy due to public preference for local species. The plantations, which basically include *Pine* sp. and *Eucalyptus* sp., represent only 0.2% of the total forest cover and does not play important role in energy supply [26].

As an attempt to regulate the production of wood fuel, the Mozambican government issued two types of harvesting licences, namely simple licence and concession licence. At present, no forest concession has been given for the production of wood fuels in Mozambique, and due to the lack of capacity to monitor the granting of simple license, the majority of charcoal consumed in major towns is illegal [10]. In 2003, the illegal production was estimated at 91–99% of the total charcoal production [19]. However, other studies [41] have reported that only 10% of the total production is official.

The charcoal is mostly produced using the earth-mount kiln, an ancient technology dating from medieval ages. During the 4–7 days necessary to produce charcoal using this type of kiln, the heat loss through radiation and unpredictable fires lowers its efficiency rates [43], which is around 15% [13].

The production of charcoal is increasing continuously. Official data (licenses) shows that between 1998 and 1999, 56% of the total wood fuel extraction was used for charcoal production, while in 2006 charcoal production represented 94% (Fig. 4).

Table 3
Energy production from biomass, 2005–2006 (PJ) [29].

	2005	2006	Change %
Firewood	282	285	1.1
Charcoal	12.4	12.7	2.0
Others	12.2	15.0	23.0
Total	307	313	2.0

Apart from many negative aspects involved in the production of charcoal, its production and trading contribute to the economy by providing incomes for rural areas, tax revenue and employment. The World Bank/ESMAP employment estimates, according to Mugo and Ong [34], that each TJ charcoal energy consumed, in person days, creates 200–350 jobs. Using the figures from Table 3, it can be accordingly estimated that between 2005 and 2006 around 3 million people (15% of the total population), were involved in the production and trade of charcoal in Mozambique. Brouwer and Falcão [13] reported that these workers were mainly demobilised soldiers and urban unemployed people.

However, despite its significant contribution, charcoal has been kept out of the formal economy [34]. The observation that charcoal does not receive the policy attention it deserves may, in part, be explained by crucial lack of baseline data and a deficit control, which transforms the charcoal business to an activity without rules, using inefficient conversion technologies and employing only poor people [45].

The combination of high demand aggravated by use of stoves with low efficiency has indirectly contributed to deforestation and



Fig. 5. Sample of the clay part of the improved stoves produced in Marracuene District.

Table 4
Production of different agricultural crops in Mozambique for 2006 and estimated potential of residue energy, calculated using residue ratio and higher heating value (HHV).

Crop	Production ($\times10^3$ tonnes) [16]	Product/residue ratio		Total residues ($\times10^3$ tonnes)	Residue (GJ tonnes^{-1})	HHV	Residue energy potential (TJ)
Sugar cane	2060	1:1.6	[58]	3297	17.9	[58]	59,007
Cotton	115	1:2.1	[58,61]	241	25.0	[61]	3834
Maize	1395	1:2.3	[60,61]	3208.5	14.7	[61]	47,165
Sweet sorghum	202	1:1.4	[58,61]	282	14.7	[61]	3672
Groundnuts	85	1:2.3	[60]	178	25.0	[61]	4443
Sunflower	7	1:2.1	[58]	15	25.0	[61]	378
Cashew nut shell	63	1:0.5	[48,49]	31	18.9	[48]	594
Tea	16	1:1.2	[58]	19	13.0	[58]	250
Coconut	47						
Shell		1:0.2	[58]	14	18.1	[58]	255
Husk		1:0.3	[47,58]	14	18.6	[58]	262
Cassava	3555	1:0.4	[61]	1422	5.6	[61]	7964
Rice	93	1:0.3	[60]	28	13.4	[59]	375

The sources are shown within parenthesis.

energy shortage in rural and peri-urban areas in Mozambique [46]. Three-stone stove is mainly used in rural areas while the traditional charcoal stove in most cases made from scrap metal cut from old car bodies, old oil drums or old iron roof is produced by local artisans spread in many parts of urban areas. They vary in form, durability, size, height and number of plates.

The country has been implementing projects to improve the efficiency of charcoal production and consumption of firewood and charcoal through introduction of improved kilns and stoves. Three stoves models (two wood stoves – Nikahluleli and xigandlambeto and one charcoal stove – xitiko) made basically from clay (inner part, Fig. 5) and metal sheet (external part) were produced, tested and disseminated in Maputo and Sofala. However, its adoption by the households still far to be considered a success.

The process of adoption of improved stoves cannot occur immediately for an entire nation or region and depends, among several factors, on involvement of local people in careful systematic work, stove attributes and management support [43].

4.1.2. Residues from agricultural sector

The Mozambican agricultural sector is characterized by a large number of dispersed small-scale producers employing manual cultivation techniques, dependent on rain-fed with little or no use of purchased inputs [24,27]. Biomass potential from agricultural harvesting and processing residues is limited, due to the lack of logistics for collecting and processing such scattered resources, which could be costly [25]. However, this is not applicable to crops such as coconut, cashew nut, rice and sugar cane which are agricultural crops with very high potential for energy and are mainly processed by entrepreneurial sector, meaning that large quantities of residues of such crops are concentrated at the same place.

Coconut fibre and shells are potential sources of energy, its weight can be estimated as one third of the nut weight [47], while the cashew nut shell is 50% of nut weight and the rest is cashew nut shell liquid (CNSL) (25%) and kernel (25%) [48,49]. Among several usages, shells can be used as a fuel in small-scale industry like bakery [48].

The estimated residue energy potential available, using product residue ratio (Table 4), for the year 2006 was 128 PJ, sugar cane and maize being the dominant crops, providing 46 and 37% respectively of total energy. The calculated energy value represents almost half of the amount of biomass energy produced in the same year (Table 3).

Traditionally, part of the residues is burned in the field as a pre-harvest measure to facilitate the harvesting process (e.g. sugar cane) or as pest control measure (e.g. cotton). Some of the residues are used as a substitute for firewood. However, there is no information about the share of different utilizations.

4.1.3. Residues from forest industries

The sawmill industry in Mozambique is characterised by small-scale enterprise with average capacity of about 10–15 m^3/day and equipped with obsolete machinery [50,51] many of them imported second hand from Portugal 30 years ago [52]. According to Eureka [50], only 30% of the log is transformed in sawn wood. However, only a very small fraction of the produced residues is used by the communities living around sawmills. The rest is in many cases, disposed off or burnt. The same study reports that this industry employs about 10,000 workers and the majority with very low level of scholar.

The potential biomass from forest logging residue is estimated at about 859 TJ or 85,000 tonnes (50% of logging residue coefficient and using a recoverability of 55%) and 175,000 tonnes/year, equivalent to 1.9 PJ from timber processing residues, considering that 64% of the log becomes waste and a recoverability of 55% [53]. Therefore, the total residue potential from logging and sawmill industries residue can reach around 2.7 PJ. This amount of energy covers part of the production of charcoal and firewood which amounted to approximately 298 PJ in 2006 (Table 3).

4.2. Liquid biofuels

The Government of Mozambique intends to promote a gradual blending of gasoline with ethanol and biodiesel with fossil diesel, initially at 5–10% [35]. For this purpose, several local crops, such as maize, sugar cane, sweet sorghum, coconut, sunflower, cassava, soya bean, cotton, and Jatropha, were identified.

A recent study commissioned by the Government to evaluate biofuels in Mozambique [54] concluded that sweet sorghum is the option of lower cost for the production of ethanol and sunflower for the same reason the most adequate for biodiesel production. The same study considered Jatropha as a promising crop and recommended further experimental trials on the production of this crop. The production of sugar cane in Mozambique still presents higher cost compared to South Africa mainly due to the lower yield which is around 60–90 tonnes/hectare.

Maize is grown by 79% of the households in almost all over the country and cassava grown by 63% and also fairly distributed as principal food crop [24]. These two crops were not considered suitable as raw material for ethanol production. The reasons, for maize, were related to its implications in food safety, high cost and market price, while cassava raised concerns about the logistics of industrial processing given its tendency for rapid fermentation.

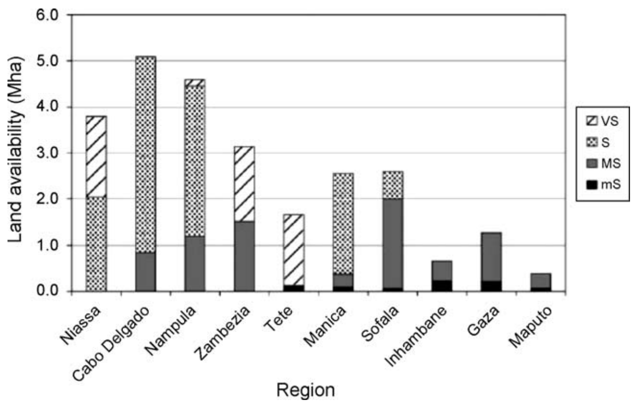


Fig. 6. Potential land availability for energy crop production by region [40]. VS – very suitable; S – suitable; MS – moderately suitable; mS – marginally suitable.

The favourable climatic conditions, the 36 million ha of arable land, of which only 13.9% are in use, and the possibility of using an additional 41.2 million ha of marginal land [35,55], have been pointed out as attractive prerequisites for biofuels production in Mozambique. The central part such as Sofala, Manica, Tete and Zambezia and northern part (Nampula, Cabo Delgado and Niassa) of the country are the most suitable areas for bioenergy production [40,54] (Fig. 6). The potential market is, however located in the south, specifically in South Africa, which makes the bioenergy produced in Mozambique in middle-short term less competitive.

The Mozambican oil company Petromoc, is projecting production of 226 million l of biodiesel a year which will cover the country's total petro-diesel consumption using Jatropha. The project will be implemented in three phases and will create about 800 jobs and will substantially reduce the country's fuel bill. Moreover, Petromoc has begun to implement a smaller biodiesel project, using coconut oil as a feedstock. The plant which is located in the Inhambane Province has a capacity of 40 million l/year.

Other international companies are investing in Mozambique's biofuel business too. Canada's Energem recently acquired a Jatropha biodiesel project based on an initial 1000 ha; it will begin planting a further 5000 ha, and invest in an additional 60,000 ha over the coming years. Chinese, Italian, Portuguese and Brazilian companies are also interested in this sector [56].

4.3. Hydropower

Mozambique has like other countries of Southern Africa, good renewable energy potential.

The hydropower generation potential is estimated at 14,000 MW (Table 5). More than 80% of total potential is located in the Zambezi valley, including the existing Cahora Bassa dam with an installed capacity of 2075 MW [34]. This power station currently supplies electricity domestically as well as to Zimbabwe and South Africa.

Mozambique generates at the present 2352 MW, of which 365 MW (net) is exported. A single consumer; the Mozambican Aluminium producer (Mozal), uses 850 MW of the total energy consumed in the country. Apart from a large-scale 2400-MW dam down the Zambezi [22] at Mepanda Nkuwa, the Government is planning to build micro and mini hydropowers projected with a potential of up to 1000 MW [35].

The construction of Mpanda Nkuwa hydropower project with an installed capacity of 2400 MW, is considered as one of the most important projects for the generation of electricity in the SADC. The hydropower will be located 61 km downstream of the Cahora Bassa hydroelectric dam. The first phase of the project, 1300 MW, is scheduled to start in January 2011 and become commercially operational by 2015 [29].

Under the energy sector program for electrification of rural areas, 83 districts headquarters of a total of 128 were electrified through national electricity grid, as well as small isolated systems based on group of diesel generators, solar systems and also through the connection to the grid of neighbouring countries. Electrification, however, has been concentrated only on hospitals, schools and upper class inhabitants, and only 13.2% of the population had in 2008 access to electricity. The majority of these consumers were located in the southern part of the country as shown in Table 6.

Besides the very limited benefits of this program, the high rise in kerosene price (Table 1) had a significant impact especially in rural areas where almost 13 million people live and the majority in extreme poverty (spending less than US$1/day). With such price increase, many of them can no longer afford it, forcing them to use fuelwood for lighting and creating unhealthy indoor living conditions.

4.4. Solar energy and wind power

There has been a significant reduction in the use of diesel for energy production in recent years, due to increased use of natural gas, expansion of the national network of electricity and to a minor impact of solar power. The global average of solar power is of 5.7 kWh/m^2/day, being the minimum average of 5.2 kWh/m^2/day (Lichinga, province of Niassa) and the maximum 6.0 kWh/m^2/day (Pemba, province of Cabo Delgado). The value of global radiation increases from south to north along the coastal line [37]. Despite the great potential, unfortunately, the solar conditions in Mozambique have been very poorly studied [37,38]. Since 2006, photovoltaic solar energy is being gradually adopted in around 300 schools and health centres in rural areas [35].

In the context of promoting clean energy, measurements of the wind power potential in the country are taking place in the Ponta de Ouro, District of Matutuíne, in Maputo Province and Tofinho, city of Inhambane, in the province of the same name. More measurements in other locations to map the national wind power potential are planned [36]. Meanwhile the National Energy Fund has been promoting the utilization of wind energy for water pumping especially along the coast and highlands of the interior. The country has also potential for both geothermal and ocean energy resources, but their exploration have not yet been considered.

The South African electricity company Eskom has invested in and completed the installation of a wind power system in the

Table 5
Renewable energy potential for selected sub-Saharan African countries [28,29,33].

Country	Solar energy (kWh/m^2/day)	Wind energy (m/s)	Geothermal (MW)	Hydropower (MW)
Malawi	–	–	50	900
Mozambique	5.7	0.9–2.6	25	14,000
Tanzania	–	3.0	–	20,000
Zambia	5.4	3.5	–	10,500
Zimbabwe	5.7	2.9	50	17,500

Table 6
Population with access to electricity by province (%), 2005–March 2008 [36].

Province	Year			
	2005	2006	2007	March 2008
Maputo	28.0	31.5	39.9	41.8
Gaza	8.2	10.2	14.0	14.6
Inhambane	3.1	4.1	5.5	5.8
Total South	15.8	18.3	24.4	25.5
Sofala	7.2	8.4	9.9	10.2
Manica	4.8	5.8	6.3	6.4
Tete	3.8	4.4	4.6	4.7
Zambezia	2.2	2.9	3.9	4.0
Total Centre	3.9	4.7	5.6	5.7
Nampula	4.15	5.68	7.0	7.2
Cabo Delgado	2.09	2.84	3.9	3.9
Niassa	3.38	4.31	4.9	4.9
Total North	3.5	4.7	5.9	6.0
Total Country	6.8	8.2	10.1	10.5

southern Mozambican province of Inhambane in August 2009. This is the first project of its kind in Mozambique, costing US$1.5 million and having the capacity to generate 300 kW of electricity. This energy is to be transformed and linked to the national power grid, and will be able to serve more than 5000 consumers, including various tourist resorts on the Inhambane beaches [39].

5. Conclusions

The country is endowed with great potential for biofuels, solar, hydro and wind energy production. However, the production today is still far from fulfilling energy needs of the country, and the majority of people are still not benefiting from these resources. Investments on wind, geothermal and solar power in Mozambique are today insignificant although these sources of energy are not competing to food production.

Presently, charcoal is one the main source of energy and it will continue to play a very important role in the near future. However, there is a need to invest more in efficient kilns for charcoal production and improved stoves in order to reduce the consumption per capita and ultimately the deforestation.

Enormous amounts of energy resources are wasted, especially from agricultural sector. These residues are not visible on national energy statistics.

The production of liquid biofuels in Mozambique is still marginal; however plans for large-scale production are underway.

Many engines in Mozambique are run mainly on diesel and can, therefore, benefit more from producing biodiesel than ethanol.

The rural electrification is still not sufficient to promote economical growth, social development and reduction of poverty of the local communities.

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